cold stream, which H. Helm Clayton has already mentioned, and which has since been often observed at the observatory.

The whole phenomenon had much resemblance, as well in its approach as also in the distribution of temperature and moisture, to the earlier mentioned inflowing fog stream from the Pacific Ocean through the Golden Gate, which has been several times observed and described by McAdie.[18]

* * * * * * *

The formation of fog on November 4, 1901, is a pure example of mixture as von Bezold has studied it. The entirely irregular march of temperature in the morning [cold below, warmer above all the forenoon] permits the conclusion that here two air currents of different temperatures flow one under the other, and this produces a noteworthy distribution of temperature. If this occurs in sufficient proximity to the condition of saturation, then condensation occurs. The fog formation began in the morning and, in spite of increased insolation, continued until evening, when the fog reached the imposing height of 340 meters. The irregular temperature march had now given way to a regular one, and overhead the condition curves showed no surprising differences from the others which in the fog had become those unusually giving rise to fog. The warm and absolutely moist, but relatively dry air column with tolerably active movement [over seven meters per second] flowed this time over the one with less vapor, and on midday of the 4th, as can be seen by the curves of wind velocity and relative humidity, made an energetic push downward whereby, through mixing with the underflowing current, condensation ensued. Thereby the vapor-air ratio naturally decreased, and thus there resulted in the fog a relatively smaller water content.

* * * * * * *

It may be said by way of recapitulation that most of the fog over the north German lowlands results from the flowing away of a moist air current over the earth's surface, which has been cooled by radiation, in such a manner that the lower cold air layers are tossed up (geschleudert) by the accompanying formation of billows, which occurs in winds near the earth, and which, by the mixture of the upper and lower layers, precipitates the fluid water. More rarely fog proceeds from the mixture of two moist currents of different temperature.

THREE NOTABLE METEOROLOGICAL EXHIBITS AT THE WORLD'S FAIR.

By JAMES H. SPENCER, Observer, United States Weather Bureau.

THE UNITED STATES WEATHER BUREAU.

The United States Weather Bureau exhibit occupies about 1000 square feet of floor space in the west end of the Government Building. Fronting, as it does, upon the main aisle, the exhibit is one of the most conspicuous in the building.

Ten instruments are operated by storage batteries, and several of them are connected to two or more registers. The outside temperature is recorded indoors by a telethermograph; the rainfall by a pluviograph; and the rainfall, sunshine, and wind velocity and direction by a station meteorograph. In order to show the method of operation, duplicates of these three registers are also connected electrically on short circuit with instruments within the exhibit space. Among the other instruments displayed are a set of self-recording thermometers, sling and whirling psychrometers, river gages, thermograph, barograph, single and double magnet registers, photographic and thermometric sunshine recorders, electric pyrheliometer, seismograph, mercurial and aneroid barometers, and a kite meteorograph, anemometer, and nephoscope. These instruments have already been fully described in various Weather Bureau publications.

A full-size Weather Bureau kite, with instruments in position, is suspended from the ceiling and connected with a reel in the usual manner.

Forecast cards are printed daily on a Harris automatic press, which has a capacity of about 15,000 per hour. These cards, and also a typical weather map and other printed matter, are distributed to visitors.

A large relief map of the United States gives the distribution of annual precipitation throughout the country. Two sets of swinging frames each contain eighteen charts or photographs, showing the climatology of the United States, cloud forms, floods, instruments, and other instructive matter.

A model storm-warning tower is displayed, with lanterns and a special hoisting attachment in position. The full-size oil-burning and electric lanterns are also exhibited.

The feature that perhaps attracts the most attention is the glass weather map. The reports are telephoned from the downtown office as fast as received by telegraph, and by 10 o'clock each morning the state of weather, current temperature, direction of wind, and rainfall from 122 stations are charted in different colors; the isobars are drawn in white. The weather conditions in all sections of the country are thus strikingly shown.

THE GERMAN EXHIBIT.

The German meteorological exhibit may be found in room D, German section, of the Educational Building. A large amount of self-recording apparatus is displayed, but perhaps the exhibits of greatest interest are the kites, rubber balloons,

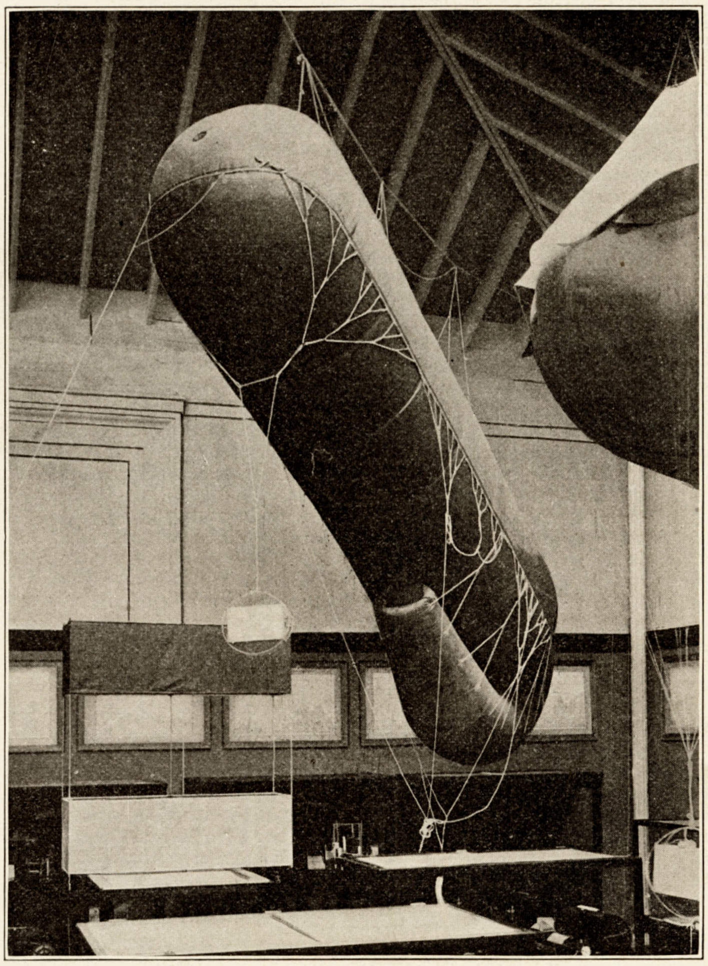

FIG. 1.—Rubber balloons.

kite balloons, and their accessories. The central figure in the accompanying photograph is the kite balloon, by the use of

[18] McAdie. Fog Studies on Mount Tamalpais, Monthly Weather Review, 1900, Nos. 7 and 11; 1901, No. 2, *and* Proceedings of the Second Convention of Weather Bureau Officials, 1903, p. 31.

which daily ascents have been made at Berlin since October, 1902, at the Aeronautical Observatory of the Royal Meteorological Institute of Prussia. The following description is taken from the German catalogue of scientific instruments:

* * * The volume of the kite balloon used in the Aeronautical Observatory is 68 cubic meters, and it is filled with hydrogen. The rear third of the cylindrical balloon, which is made of rubber-filled cotton stuff, is separated from the rest of the balloon by a ballonet, which is filled with air by the wind through an opening in its lower surface. A valve of cloth prevents the air from escaping. The pressure of the air thus forced in is communicated to the gas and gives the balloon a rigidity that enables it to act as a kite. Even in very stormy winds it is hardly ever forced below an angle of 30-35°. The steering sack, which is also automatically filled with air, and the tail, which is composed of wind funnels, serve to diminish side motions. * * *

One of the rubber balloons designed to carry self-recording apparatus to a height of 20,000 meters is shown in part at the right of the photograph.

Both of the balloons shown in the photograph are rigged for ascensions with the self-registering instruments in place. Note that the instruments of the rubber balloon are attached to the parachute (the white cover). The ordinary box kite is shown in the lower left-hand corner. The charts on the walls give data prepared from records obtained from balloon flights.

The following descriptions of balloons and apparatus are also taken from the catalogue of scientific instruments of the German educational exhibition:

Rubber balloons.—According to Assmann, for carrying registering apparatus to a height of 20,000 meters.

The balloons, of from 1200 to 2000 millimeters diameter, are made of Para-rubber; the weight is from 1365 to 3230 grams; the volume one to four cubic meters. They are filled with pure hydrogen and closed. A rubber balloon filled in this way and allowed to rise increases its volume until it bursts. This happens, in general, when its natural diameter is increased about two and one-half times, which corresponds to an increase in volume of fifteen and six-tenths times. The corresponding air pressure is 50 millimeters, which is attained at a height of about twenty kilometers. The apparatus falls unharmed to earth, supported by a parachute, which is spread above the balloon. These are made in bright colors that they may be more easily found.

For ascensions up to 8000 meters a light spring valve is inserted in the filling tube, and is opened automatically by means of a cord in the interior of the balloon when the balloon has expanded until its diameter is equal to the length of the cord. The gas escapes under the elastic pressure of the rubber only until the balloon has reached its natural diameter, and the balloon then sinks slowly to earth. Since the balloon does not burst a parachute is not necessary, and it can be used for four or five ascensions, as the rubber is not overstrained. The great advantage of the rubber balloon over others is that it never reaches a position of equilibrium in which the natural ventilation due to the vertical motion ceases so that the thermometer is affected by the solar radiation. The average velocity in ascending and descending is about five meters per second; thus an ascension of fifteen kilometers is finished in one hour and forty minutes. This prevents the balloon from falling at any great distance from the point of departure.

At times two balloons, filled to different degrees with gas, are connected in "tandem" so that after the bursting of the larger balloon the other serves to bring the apparatus down and is of use as a signal in its recovery. It also serves as a float if it falls in the water. Accompanying these advantages are the disadvantages that the descent is much slower, and consequently the apparatus may be carried a long distance horizontally and in windy weather injured by being dragged along the earth. It is also possible that *both* balloons may burst, in which case of course the apparatus is ruined.

Registering apparatus for kites, with new anemometer.—According to Assmann, designed in the workshop of the Aeronautical Observatory.

A vertical tube of polished aluminum, bent forward above against the wind, and backward below, contains a circular thermometer element, made by soldering a strip of Guillaume nickel steel (mark "Invar") to a similar strip of copper. The large difference in expansion of the two metals produces a considerable motion of the free end of the open ring. This motion is enlarged by a nickel steel lever and transmitted to a registering pen which is held by a silk thread stretched between two pulleys. In the same way the motions of a hair hygrometer, situated in the same tube, and of a set of three aneroids are recorded. A powerful clockwork draws the thinnest possible register-paper from a magazine-roller above and winds it on a roller below. The length of the paper is one and one-half meters. The registering pens stand one above another, so that almost the whole width of the paper is used. The coordinates of the curves are at right angles. The temperature is registered in red, the pressure in violet, and the moisture in green ink. A blotting roller prevents the blotting of the curves. At one edge of the paper ten minute time marks (1 min. = 1 mm.) are recorded, on the other edge the wind velocity is recorded, a mark being made after every 9800 revolutions of the Woltmann fan in the anemometer. This corresponds to three and twenty-one hundredths kilometers. The anemometer is situated in the upper part of the protecting tube. A magnalium case prevents the entrance of rain and serves to fasten the apparatus in the front part of the kite. The back wall is open to prevent wind resistance. The weight of the apparatus, which according to the length of the registering paper permits of ascensions of twenty-four hours or more, is 1200 grams.

Registering apparatus for rubber balloons.—According to Assmann, designed in the workshop of the Aeronautical Observatory.

The arrangement and transmission of the copper-Invar thermometer element, as well as the support of the recording pens on stretched silk threads, are the same as in apparatus No. 5. The motion of the registering paper is not produced by clockwork, but by the aneroids themselves on account of the change in the air pressure. The recording paper in the form of an endless rouleau is covered with lamp black, and is held stretched between two rollers. A third pen, driven by a light clockwork, draws a line across the whole width of the paper every two hours. Each of the three curves contains the air pressure as a second element. As it is important to differentiate the curves of ascent and descent, the recording pens are automatically lifted from the paper when the air pressure during the latter reaches 600 millimeters. This also prevents a blotting of the paper in landing and in the transportation of the apparatus. The funnel-like openings of the protecting tube above and below allow a free circulation of the air in ascending and descending. In this way the thermometer and hygrometer are protected from the influence of the rays of the sun. An ascension velocity of three or four meters per second is sufficient to prevent errors from radiation, and the velocity becomes greater than this as the balloon ascends. The time-pressure curve indicates the velocity of vertical motion, and if it is pointed at the greatest height indicates that the balloon has burst. In other cases there is a gradual change of direction. A light magnalium case, provided with a lock and protected against danger in landing by two wicker rings, serves as a protection against rain and careless handling by the finder. An envelope contains a despatch form and the information that a reward will be paid if the case is returned unopened.

The apparatus ready for use weighs 620 grams.

Triple balloon aspiration psychrometer.—According to Assmann, designed by R. Fuess, Steglitz.

The rapid changes of temperature and humidity during the vertical movements of the balloon make the observation of the psychrometer over any length of time unreliable on account of the difficulty of keeping the wet thermometer bulbs supplied with water. To obviate this difficulty, the balloon instrument is supplied with *two* wet-bulb thermometers which can be read alternately. For very low temperatures (under —20° C.), where the psychrometer becomes unreliable, a hair hygrometer, protected from radiation, is used. In order to prevent errors, a metal plate is placed over the scale of the thermometer last moistened. This plate serves also to reflect light on to the scale when it stands in shadow. The psychrometer, which is hung on a swinging arm at a distance of one and six-tenths meters from the edge of the car to protect it from temperature disturbances due to the observers, is read with a telescope.

REGISTERING APPARATUS FOR SCIENTIFIC INVESTIGATION OF THE UPPER ATMOSPHERE.

The following pieces of apparatus, designed in accordance with the plans of Professor Hergesell, in Strassburg, are remarkable for their great accuracy and sensitiveness as well as for their lightness. Their thermal capacity is so small that even when the temperature changes are very great they indicate the correct value within a few seconds.

Barothermograph for exploring balloons (balloons sondes).—This apparatus registers continuously the pressure and the temperature on the same drum. The thermometer is more than sufficiently ventilated and protected from radiation by the motion of the balloon itself. The driving mechanism is inclosed in a case for protection against cold. Weight, with protecting case, 630 grams. The apparatus can be raised by means of a rubber balloon of one and one-half meters in diameter to a height of 20,000 meters.

Barothermohygrograph for balloon ascensions.—The apparatus registers the air temperature, pressure, and moisture continuously on the same drum. By means of artificial ventilation and protection against radiation, the thermometer registers the correct temperature even in the strongest sunshine. The hygrometer is also artificially ventilated. The ventilation may be kept in action for several hours by means of a few galvanic cells or accumulators of small weight. Weight of the whole apparatus, one and six-tenths kilograms. The energy required for the production of artificial ventilation for a year costs only about 50 marks.

The instrument is also constructed without a barometer for use in meteorological stations.

Standard aspiration psychrometer.—According to Assmann. With arrangement for use in the Tropics.

Two mercury or alcohol thermometers with small cylindrical bulbs are each placed in two short, concentric, highly polished protecting tubes, thermally insulated from each other. These protect the thermometer from radiation. A centrifugal aspirator, run by clockwork (25 turns per second) draws an air current of from two to three meters per second past the thermometers inside the protecting tubes. This removes the radiation heat that has not been reflected by the protecting tubes, so that even in the strongest sunshine (at great heights, on mountains, in balloons, as well as in the Tropics) the true air temperature is measured. One of the thermometer bulbs is wrapped in muslin and from time to time moistened with water. The vapor tension is calculated from Sprung's formula $f=f'-\frac{1}{2}(t-t')\,b/755$. For use in the Tropics, two extra springs and thermometers and a moistening apparatus are furnished.

Bolometric apparatus for the measurement of the total radiation.—In order to measure the radiation from a glowing body, which it sends out to its environment in the form of ether waves, a very sensitive instrument is required, which transforms the energy of the oncoming waves into heat, and by means of its rise in temperature allows this energy to be measured.

The bolometer, according to Lummer-Kurlbaum, consists of platinum foil 0.001 millimeter in thickness, covered with spongy platinum, in order that all wave lengths may be absorbed equally. The four arms of the bolometer are combined into a Wheatstone bridge. These are all as much alike as possible, in order that the balance of the bridge shall not be affected in any appreciable degree by the variations of the room temperature or the variations in strength of the measuring current. In consequence of this and on account of the small thermal inertia and extraordinary thinness of the strips, a radiation that produces a heating in the bolometer of only 0.00001° C. can be measured with an accuracy of a few per cent. In addition to the bolometer, the stand holds a blending apparatus and a shutter, provided with water cooling.

THE PHILIPPINE WEATHER BUREAU.

This exhibit occupies a building of its own. The map section is especially interesting and elaborate. An outdoor relief map of the Philippines occupies a space 110 feet long by 70 feet wide just back of the building. There are also eight smaller accessory relief maps of the islands, showing: (1) The average rainfall in the Archipelago and prevailing winds on the seas during February, the driest month of the year; (2) during August, the wettest month of the year; (3 and 4) the political and religious divisions; (5) the relative earthquake frequency; (6) mines and mineral springs; (7) forestry and agriculture; (8) ethnography. Other maps show Manila Bay; the Volcano and Lake Taal; Manila and surrounding towns; the distribution of rainfall in the Archipelago; typhoon tracks, etc.

A number of the Manila Observatory publications are displayed.

On each side of the building is a high tower. A Robinson anemometer is at the top of one and the transmitting portion of Richard's anemocinemograph is at the top of the other.

A microseismograph, built at the Manila Observatory, is shown in operation. This instrument is a copy of the grand microseismograph of Vicentini, with the vertical component modified by Rev. Father Algué. Twenty additional instruments are displayed, including Rev. Father Algué's refraction nephoscope, barocyclonemeter, and typhoon barometer. Rainfall, lightning, sunshine, earthquakes, temperature, atmospheric pressure, and the direction, velocity, and force of the wind are recorded by self-registering apparatus.

Both Father Fenyi's and Father Odenbach's ceraunographs, or lightning recorders, are also exhibited.

THE DIGNITY OF THE SERVICE.

Address by Mr. JAMES H. SCARR, Observer, at the Weather Bureau Banquet, Peoria, Ill., September 22, 1904.

When I speak of "Dignity" I do not refer to that so-called dignity whose chief stock in trade consists of a silk hat and kid gloves. These and more are but the adjuncts of dignity, and in proper time and place possess a value not to be underestimated. But I would speak of that dignity which comes from a sense of responsibility for the performance of a duty—not only agreeable and satisfying, but imperative and valuable—the dignity that comes from a faith in the absolute integrity of purpose behind the work sought to be performed, and the exercise of every energy to bring that work to perfection.

Let me speak of the man as the visible sign of the Service, the stereoscope, if you please, through which the public views and forms its estimate of the Service.

The true dignity of the Service may be as high above the man charged with its duties as the heaven is high above the earth, but the public estimate of that duty will, for a long time to come, be measured by the public's opinion of the men who represent it.

The weather has so long been the synonym of uncertainty and fickle changeableness, that signs and portents (possibly of some value in the locality of their origin) have obtained a firm hold upon the public mind, so that it is not too much to assert that the service that seeks to reduce the weather changes to rule and foretell their occurrence by the application of known physical-laws, must, for a time at least, borrow its dignity from the men who represent it.

The man is wholly unworthy the work in which he is engaged, who fails to dignify that work with his very best effort. Not only must he so dignify his profession, but he must be deeply impressed with the fundamental truth that his best is good enough only so long as it is equal to the demand made upon him.

I know of no position in any community that demands more than that occupied by the representative of the United States Weather Bureau. It is only by the constant, faithful, and accurate response to these demands that the true dignity of the Service can be, and will be, established and maintained.

He must be a good citizen, sober, industrious, and moral; keeping carefully aloof from sectional or factional alliances or prejudices; resisting kindly but firmly every effort of local pride or rivalry to build up its particular climatological reputation by the suppression or garbling of conditions prevailing there or elsewhere. He must bear in mind that his principal duty to the community is the collection and dissemination of climatological and current weather data, in their special relation to the business of that particular community, and that the dissemination of such data must be timely, reliable, and impartial.

Neither must his dignity be always of the ministerial sort that invariably frowns upon the "Weather Joker." Let him have his joke so long as it contains no poison; it may afford an opportunity to point a lesson, strengthen a friendship, and advance the interests of the Service.

He must put the Service before self. In every public service the *man* becomes but the instrument of operation, and if found unsuited to the field in which he is employed, he must give way to another. It matters not, so far as procedure and results are concerned, whether the lack of adaptability be the fault of the instrument or of the field. It is much easier to change instruments than to reform fields.

He must be loyal. Put this down as fundamental. Nothing can exert such a disintegrating, demoralizing influence upon the Service as disloyalty. Assistants must be loyal to the officials in charge of the stations on which they serve. Observers and local forecasters must be loyal to the district forecaster. But above all be loyal to our honored Chief, than whom no man has done more to set up and maintain a high standard of dignity, and than whom no man could have done more to increase the efficiency and practical utility of the Service, while conserving, in so far as its hard exigencies permit, the personal interests of every man in it.

Remember, too, that the Service stands before the uninformed public, identified and measured by its failures. In the mind of that public the weather forecaster is not exempt from that stern but inexorably written law, "He that offendeth in one point is guilty of all." Let one serve his friend with devotion and singleness of purpose through the years of a long life, but never so unwittingly fail him in one instance, and the service of a lifetime is found wanting when weighed in his balance against the one failure.